

# **INFORMATIONAL LEAFLET NO. 237**

RECOVERY DISTRIBUTION OF CHUM SALMON (Oncorhynchus keta)  
TAGGED IN THE NORTH PACIFIC OFFSHORE OF THE  
ALASKA PENINSULA AND EASTERN ALEUTIAN ISLAND CHAIN

By

Linda K. Brannian

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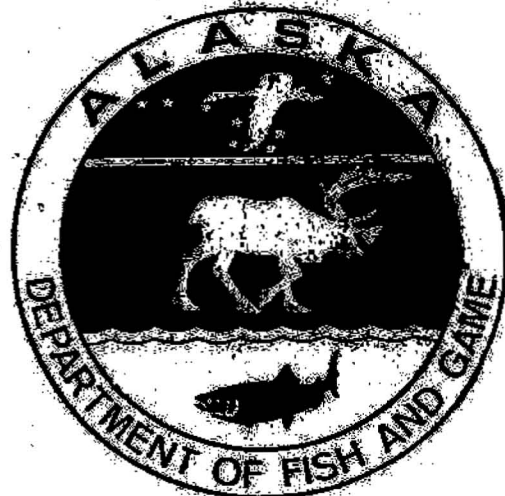
STATE OF ALASKA

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May 1984

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## ABSTRACT

The International North Pacific Fisheries Commission (INPFC) has for many years sponsored an extensive program to tag salmon on the high seas. Much of its effort has focused on areas of interception in order to develop an understanding of salmon distribution and their pattern of movements. Chum salmon (*Oncorhynchus keta*) were tagged by INPFC member countries in the vicinity of the Alaska Peninsula and Eastern Aleutian Island chain from 1956 to 1966. Within this study area the greatest tagging effort occurred in the Pacific Ocean offshore of Umnak and Unalaska Islands. Recoveries from these tag releases were made throughout Western Alaska and along the Asian coast. Differences in arrival time could be discerned for the various chum salmon stocks being tagged. Summer run chum salmon from the Yukon River dominated the recoveries from May and early June releases. Norton Sound and Kuskokwim Bay chum salmon stocks were available for tagging throughout June. Bristol Bay chum salmon stocks appeared somewhat later with most recoveries made from the mid to late June releases. Yukon River fall run chum salmon were available for tagging in mid to late June. Tag recoveries of Kotzebue chum salmon were from the releases made mid June to early July. The percentage recovered by area could not be applied directly to determine the stock composition in the tagging area because of the failure to meet several important assumptions. Some of these assumptions were: (1) all stocks must be equally vulnerable to capture for tagging, (2) equal recovery rates must be applied in all areas, and (3) post-tagging mortality and tag loss must be similar for all stocks.

KEY WORDS: chum salmon, *Oncorhynchus keta*, mark-recapture, interception, Alaska Peninsula, Aleutian Islands, Yukon River, Norton Sound, Kuskokwim Bay, Bristol Bay.

## INTRODUCTION

Prior to the 1960's, chum salmon (*Oncorhynchus keta*) were used primarily for subsistence in Western Alaska mainly as food for sled dogs. Commercial fisheries for Western Alaska chum salmon expanded in the 1960's as fishing effort increased, processing capabilities improved, and new markets were established in Japan. The largest catches, north of Bristol Bay, have occurred in the Yukon River which supports both summer and fall chum stocks. A dramatic increase in the Yukon River commercial chum salmon catch took place in 1969 with a steady increase thereafter (Table 1). The largest Yukon River catch occurred in 1981 when nearly 1.7 million chum salmon were harvested. Combined catches in the Kotzebue-Norton Sound area have greatly increased, reaching 847,000 fish in 1981. The commercial chum salmon fishery in the Kuskokwim area expanded sharply in the 1970's and has produced an average catch of 395,000 chum salmon during the 1979-1983 period. In Bristol Bay, the commercial catch of chum salmon increased dramatically in 1976, staying near a million thereafter. The expanded Western Alaska chum fisheries are expected to fully utilize the resource in the 1980's. In general, the recent trend in all areas is for increased catches per unit of fishermen effort because of efficiency improvements while fishing time allowed per season by the management agency has decreased.

Additional pressure is exerted on Western Alaska chum salmon stocks by several interception fisheries. The Japanese mothership salmon fishery operates in the Bering Sea as well as in the North Pacific Ocean, harvesting 2-4 million chum salmon annually as well as other salmon species. The harvest may include Western Alaska chum salmon (Fredin et al. 1977). In addition, domestic fisheries along the Alaska Peninsula intercept non-local stocks especially in June. Most noteworthy are the South Unimak and Shumagin Island salmon fisheries which have been in operation since 1911. The combined average June chum salmon harvest from South Unimak and the Shumagin Islands has been 602,000 fish for the 1979-1983 period, an increase over the historic average of 249,000 for 1962-1978 (Table 1). Harvest guidelines for the South Unimak and Shumagin Island June sockeye salmon fisheries are currently established as 6.8% and 1.5%, respectively, of the latest projected Bristol Bay inshore sockeye salmon harvest. While most fishermen target upon the more valuable sockeye salmon, chum salmon are taken incidentally. In 1982, all time record catches of 875,000 and 140,000 chum salmon were made in the South Unimak and Shumagin Islands, respectively, in the month of June and again in 1983 large catches of 619,000 and 169,000 chum salmon were made (Table 1).

Increased harvest pressure in both the terminal and interception areas has placed additional allocation responsibility on fisheries managers. Considerable user group controversy could develop if the recent increased harvest levels in the interception fisheries are not coupled with the achievement of high harvest levels in terminal areas. The recent extremely large interception harvest on the Alaska Peninsula and the fact that average to poor chum salmon harvests were attained in some Western Alaska fisheries have focused considerable attention upon the South Unimak and Shumagin Islands salmon fisheries in 1982 and 1983. Two explanations have been proposed for the large interception catches. One is that the fishery is somehow targeting on chum salmon whose harvest is not limited by the guideline harvest levels set for sockeye salmon. An alternative explanation proposes that the chum salmon catch is purely incidental to the taking of sockeye salmon. The

Table 1. Commercial catch of chum salmon by area for Western Alaska, 1962-1983 (thousands of fish).

Year	Kotzebue	Norton Sound	Yukon River <sup>1</sup>	Kuskokwim Bay <sup>2</sup>	Bristol Bay	June Fisheries	
						Shumagin	Unimak
1962	130	183	53	46	668	61	209
1963	54	155	0	0	370	36	81
1964	76	149	8	1	803	67	161
1965	40	37	23	4	361	45	121
1966	31	80	71	3	343	17	215
1967	29	42	49	8	476	51	73
1968	30	45	67	20	364	51	115
1969	59	83	192	50	333	13	254
1970	160	107	347	61	718	49	403
1971	155	131	290	99	677	115	554
1972	170	101	288	97	657	108	468
1973	375	119	518	184	684	23	189
1974	628	162	879	196	286	0	15
1975	563	212	985	224	325	36	65
1976	160	96	762	232	1,329	74	327
1977	196	200	798	299	1,598	22	93
1978	112	189	1,289	282	1,158	18	105
1979	142	141	1,166	297	907	41	64
1980	367	181	1,356	561	1,405	71	457
1981	677	170	1,678	486	1,475	54	521
1982	418	183	839	325	941	140	875
1983 <sup>3</sup>	176	319	1,203	307	1,467	169	619
Average (62-79)	175	112	389	106	656	46	203
5 year Average (79-83)	356	199	1,248	395	1,239	95	507

<sup>1</sup> Does not include Canadian catches.

<sup>2</sup> Includes catches made in the Kuskokwim River, Kuskokwim Bay, Quinhagak Bay and Goodnews Bay.

<sup>3</sup> From preliminary season summaries.

recent large sockeye salmon returns to Bristol Bay have greatly increased the allowable sockeye salmon catches and at the same time the incidental chum salmon catch has increased. Any future allocation scheme for chum salmon must be based on knowledge of the migration routes, timing differences, run strength, and final destination of the chum salmon passing through the interception fisheries.

Limited tagging studies have been conducted along the Alaska Peninsula and Aleutian Island chain (Gilbert and Rich 1925, Thorsteinson and Merrell 1964). These indicate that most of the sockeye and chum salmon available to the June South Unimak and Shumagin Island fisheries are of a non-local origin. Gilbert and Rich (1925) tagged chum salmon in early July off Unga Island which were recaptured over most of Western Alaska and Kamchatka. In contrast only local recoveries were made of chum salmon tagged during the second week of July off Unimak Island and the southwest shore of the Alaska Peninsula. The U.S. Fish and Wildlife Service conducted tagging studies in this area in 1961 which resulted in a similar recovery pattern (Thorsteinson and Merrell 1964). In 1961 tagging was conducted from 15 June to 14 July along Unimak Island and the southwest shore of the Alaska Peninsula. Recoveries were made from such distant areas as Norton Sound, the Yukon and Kuskokwim Rivers, and from nearby locations along the southern shore of the Alaska Peninsula (Table 2). Neither the time span over which tagging was conducted, nor the magnitude of the recoveries allows an analysis of differences in timing for the various stocks.

In addition to the previously mentioned tagging studies conducted by U.S. agencies, extensive research has been conducted under the coordination of an international organization. The International North Pacific Fisheries Commission (INPFC) was established by the International Convention for the High Seas Fisheries of the North Pacific in 1952. Participating nations include Canada, Japan, and the U.S. The three member countries have joined in major research programs to study salmon on the high seas. An extensive program has been underway for many years to tag salmon on the high seas and in areas of interception to develop an understanding of their distribution and pattern of movements. This report will present the results of chum salmon tagging studies in the vicinity of the southwest portion of the Alaska Peninsula and the eastern portion of the Aleutian Island chain.

#### INPFC TAGGING OF CHUM SALMON

Recovery information is available from high seas tagging conducted over the period 1956-1982 (Aro et al. 1971, Aro 1972, 1974, 1977, 1980; Meyer 1983). The tag release area of interest for this paper is a rectangle enclosing the southwest portion of the Alaska Peninsula and Eastern Aleutian Island chain (Figure 1). Of specific interest were tag recoveries from releases made adjacent to the Shumagin and Unimak Islands, however, the greatest tagging effort within the study area occurred in the Pacific Ocean between longitude 165°W and 170°W (Figure 2). Historically, release data have been available for each recovery and have consisted of a computer file listing of date, latitude, longitude, agency code, gear type used for capture, and tag number of release. Recovery data have consisted of date, latitude, longitude, and the recapture gear type. Biological data were also collected when possible at the time of release and recovery. This included species, length, age determination by examination of scales, sex, weight, and gonad weight.

Table 2. Chum salmon release and recovery data from tagging conducted offshore from Unimak Island and the southwestern coast of the Alaska Peninsula in 1961 (Thorsteinson and Merrel 1964).

Tagging location	Inclusive tagging dates	Number released	Number of Recoveries by Area							Total Recovered
			Norton Sound	Yukon River	Kuskokwim Bay	Bristol Bay	Alaska North	Peninsula South	Japan	
Cape Lutke	June 16-July 4	689	0	4	4	17	3	2	0	30
Unimak Bight	June 19	33	0	1	1	0	0	3	0	5
Cape Lazaref	June 15-16	19	0	1	0	2	1	0	0	4
Cape Pankof	June 16-July 4	162	1	3	1	0	1	4	0	10
Ikatan Bay	July 6-13	26	0	0	0	0	0	2	1	3
Morzhovoi Bay	July 8-14	8	0	0	0	0	0	2	0	2
Deer Island	June 28-July 12	56	0	0	0	1	1	4	0	6
Total		996	1	9	6	20	6	17	1	60
Percent of Recoveries			2	15	10	33	10	28	2	

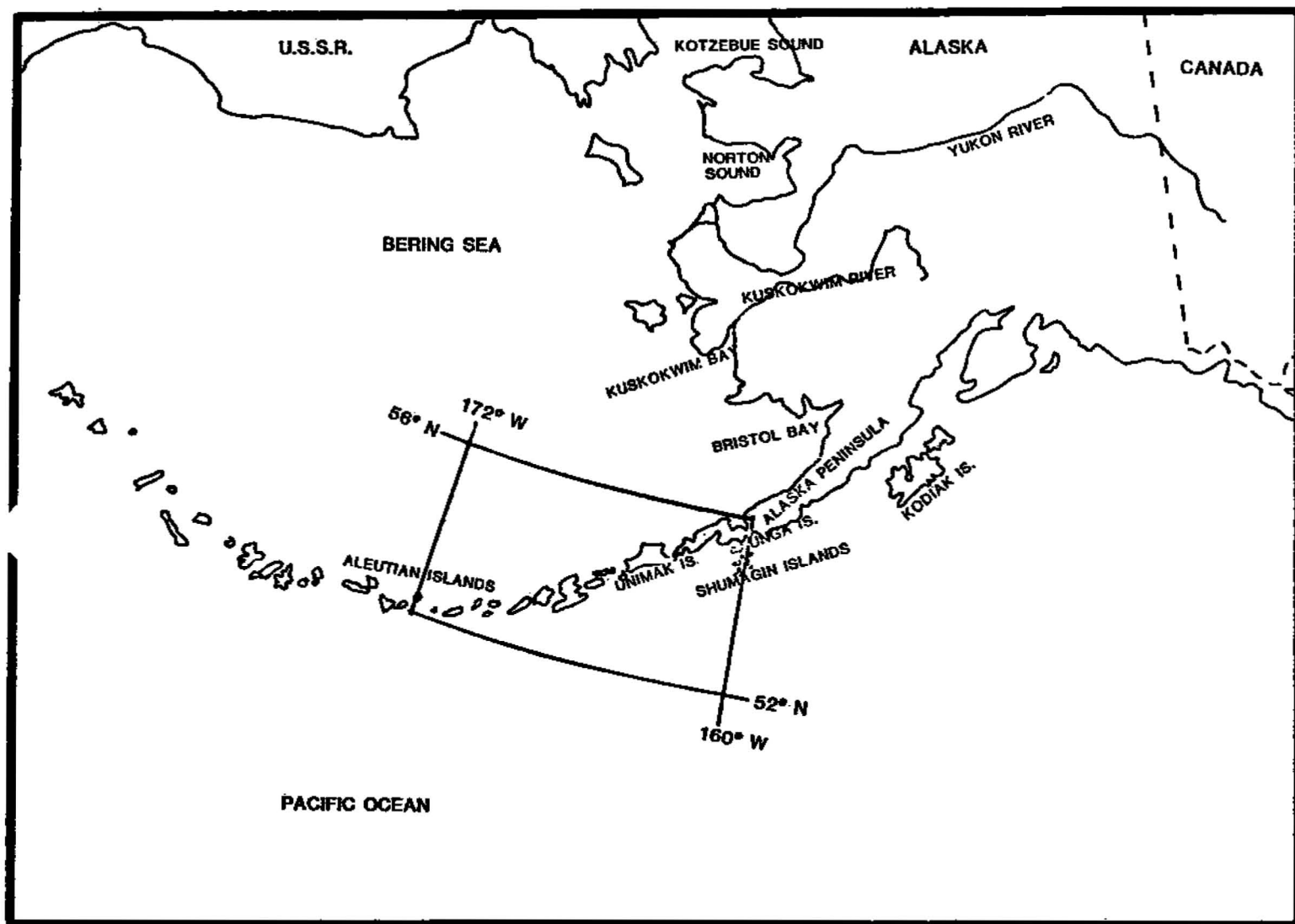


Figure 1. Area of interest for distribution analysis of INPFC studies conducted, 1956-1966.



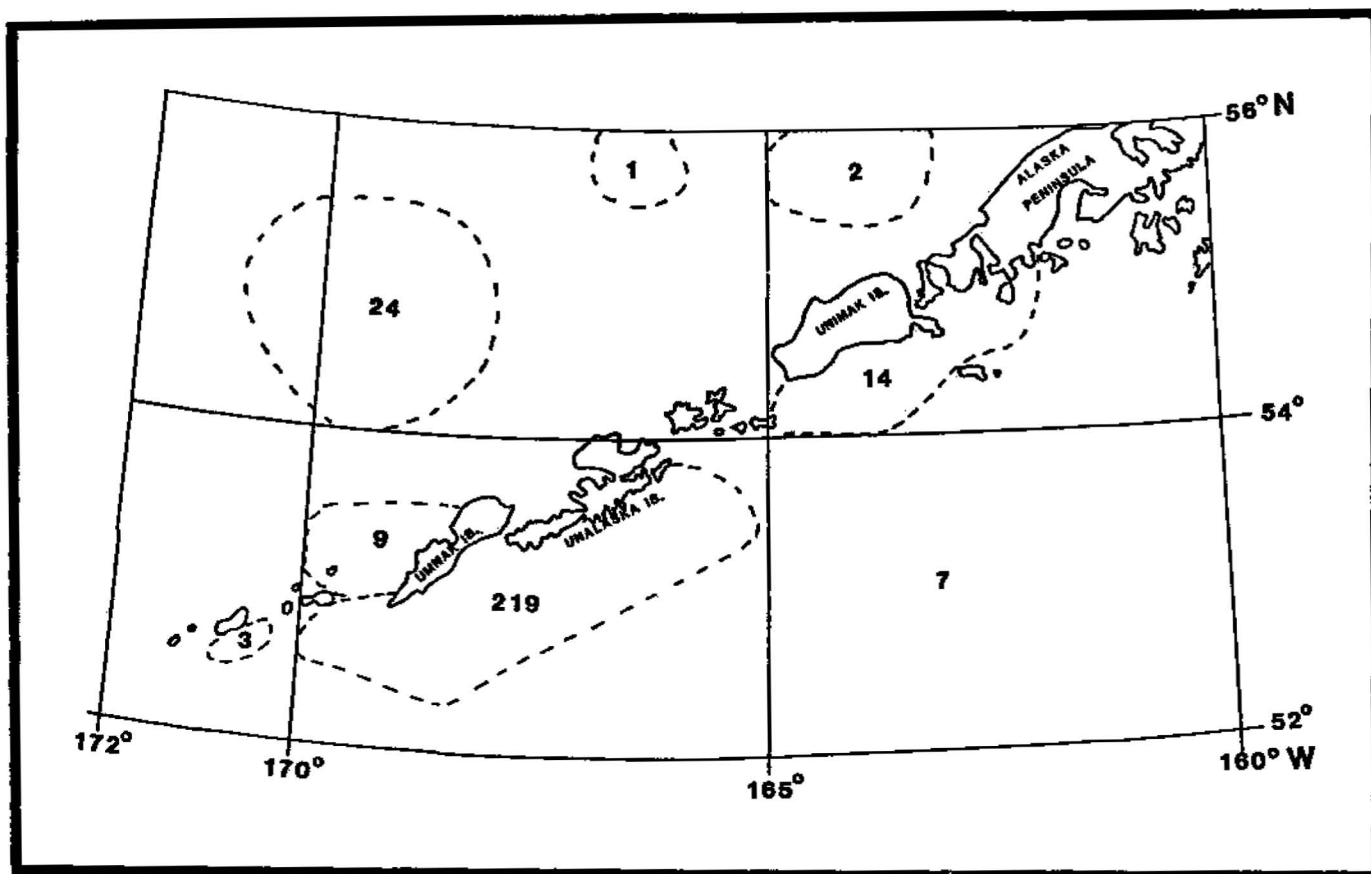


Figure 2. Areas of release for 279 tagged chum salmon recovered from INPFC sponsored studies of 1956-1966. Number of recoveries from each area is indicated. The area south of Unalaska and Umnak Islands include two recoveries made between the Kuskokwim and Yukon areas and one recovery each from the Strait of Georgia and Puget Sound.

See Appendix A for the description of area codes (Appendix Table 1) and the date and location of release and recovery for each chum salmon recovered from tagging conducted in the area adjacent to the Alaska Peninsula and Aleutian Island chain (Appendix Table 2).

Recoveries of chum salmon tagged in the study area were grouped as to the following recovery areas for purposes of this report:

- Kotzebue Sound: Includes recoveries along the shore and within systems draining into the area north of Cape Prince of Wales.
- Norton Sound: Includes recoveries from along the shore and within drainages from Cape Prince of Wales to Stuart Island.
- Yukon River: Includes recoveries in the Yukon River drainage.
- Kuskokwim Bay: Includes recoveries in the Kuskokwim Bay and River and minor systems draining into the bay.
- Bristol Bay: Includes recoveries made from Cape Newenham to Ugashik Bay including all systems draining Bristol Bay within this region.
- North Alaska Peninsula: Includes recoveries made west of Ugashik Bay to Unimak Pass on the north side of the peninsula.
- South Alaska Peninsula: Includes recoveries west of Shelikof Strait off Kodiak Island to Unimak Pass on the south side of the Alaska Peninsula.
- Asian Coast and Japan: Includes recoveries made off the Western Pacific Ocean and Bering Sea coasts or the drainages of Russia and Japan.
- High Seas: Includes all recoveries made on the high seas and Aleutian Island chain west of Unimak Pass.

The time period for analysis is limited to 1956-1966 because only in those years were substantial recoveries made from tagging conducted in the study area. Ninety percent of the recoveries were from tagging conducted by the Fisheries Research Institute (FRI) of the University of Washington under contract to the Bureau of Commercial Fisheries of the United States Fish and Wildlife Service. The remaining recoveries were of tags placed by the Fisheries Agency of Japan or in case of only two recoveries by the Fisheries Research Board of Canada. The primary method of capture used by FRI was a purse seine while longline gear was used by the Japanese Fisheries Agency. A total of 309 recoveries was made of which 90% occurred in the same year of tagging. Thirty tags were recovered in subsequent years implying that some immature fish were present in the study area. All discussion on the recovery distribution is based on recoveries made in the year of tagging unless otherwise specified.

## RESULTS AND DISCUSSION

### Recovery Distribution from INPFC Tagging Studies

Recoveries of tagged chum salmon were grouped by the recovery areas previously defined to evaluate their distribution. The greatest number of recoveries were made along the Asian Coast and Japan (87) followed by the Yukon River (58) and Bristol Bay (56) areas (Table 3). A comparison of Asian and Alaskan recoveries indicates that 174 were Alaskan recoveries comprising 67% of the total (high seas recoveries were excluded). The recovery percentage by area varied greatly between years (Table 4) which is to be expected with the low number of recoveries in several years. When data from all years were pooled, three areas of recovery dominated with the Yukon River comprising 21%, Bristol Bay 20%, and the Asian Coast and Japan 32%. No recoveries were documented from the southern shore of the Alaska Peninsula and few along its northern shore. In addition, no recoveries were made along the Aleutian Island chain west of Unimak Pass.

It is of some interest to further delineate the release area for the tagged chum salmon recovered over the years 1956-1966. The release areas for the 275 recoveries of Table 3 are defined in Figure 2. We initially subdivided the study area shown in Figure 1 into six rectangular areas bordered by latitude lines 56°, 54°, and 52° N and longitudinal lines 172°, 170°, 165°, and 160°W (Figure 2). Since recovered chum salmon were actually released in more restricted subareas for which specific locations are available release areas were bordered with dashed lines. The number of recoveries from each area is indicated in Figure 2. From Figure 2 it is apparent that most of the recoveries were made from tagging conducted just offshore of Unimak and Unalaska Islands. In contrast, few recoveries were made from tagging conducted near Unimak Island. Recovery distribution from the six rectangular release areas is presented in Table 5. Total release information was available for the six release areas but not for any finer delineation (dashed line areas of Figure 2). Yukon (58), Kuskokwim (23), and Bristol Bay (56) recoveries were made from releases in all areas east of 170°W (Table 5). In addition, Asian recoveries are notably missing from releases in the Unimak Island area (Table 5) even though most releases were made in June when Asian fish seem to pass through the area (Harris, personal communication). The extremely low sample size outside of the Unalaska area precludes any statistical statement about differences between release areas in their recovery distribution.

To better compare the recovery distribution with other studies, all years were pooled and viewed by time period for which total release numbers were available. Release information for May through July was available by period which was defined as three per month and consisted of at least 10 days. The seasonal duration of the INPFC tagging was far greater than in other studies (Gilbert and Rich 1925, Thorsteinson and Merrell 1964) ranging from 1 May through September. Timing differences for tag placement can be seen for chum salmon from the various recovery areas. Throughout the May release periods, the Yukon River was the predominant area of tag recovery (Tables 6 and 7), while in the first period of June nearly an equal number of recoveries were made in the Yukon River (13) and Asian Coast (12) areas. A similar level of recovery was made in Bristol Bay and the Asian Coast areas from tagging throughout the remainder of June. Tagging in the month of July and thereafter resulted in few recoveries (Tables 6 and 7).

Table 3. Number of INPFC chum salmon released and recovered from tagging studies conducted in the area adjacent to the Alaska Peninsula and Aleutian Island chain, 1956-1966. Only recoveries made in the year of tagging are presented.

Year Tagged	Number Released	Number of Recoveries by Area									Total Recovered
		Kotzebue	Norton Sound	Yukon River	Kuskokwim Bay	Bristol Bay	Alaska North	Peninsula South	Asian Coast and Japan	High Seas	
1956	1,093	0	0	9	9	8	2	0	4	2	34
1957	793	0	0	0	1	0	2	0	5	0	8
1958	1,607	0	0	0	0	0	0	0	4	0	4
1959	268	0	1	4	2	0	0	0	2	0	9
1960	3,463	11	1	19	8	25	4	0	25	5	98
1961	1,740	5	5	9	1	15	1	0	19	0	55
1962	966	3	2	12	2	7	0	0	26	1	53
1963	147	0	0	1	0	0	0	0	0	0	1
1964	39	0	0	0	0	0	0	0	1	2	3
1965	129	0	0	3	0	1	0	0	1	4	9
1966	11	0	0	1	0	0	0	0	0	0	1
Total	10,256	19	9	58	23	56	9	0	87	14	275 <sup>1</sup>

<sup>1</sup> Does not include two recoveries made between the Kuskokwim and Yukon area and one recovery each from the Strait of Georgia and Puget Sound.

Table 4. Percentage of INPFC chum salmon released and recovered from tagging studies conducted in the area adjacent to the Alaska Peninsula and Aleutian Island chain, 1956-1966. Only recoveries made in the year of tagging are presented.

Year Tagged	Percent Recovered By Area								
	Kotzebue	Norton Sound	Yukon River	Kuskokwim Bay	Bristol Bay	Alaska North	Peninsula South	Asian Coast and Japan	High Seas
1956	0	0	26	26	24	6	0	12	6
1957	0	0	0	13	0	25	0	62	0
1958	0	0	0	0	0	0	0	100	0
1959	0	11	45	22	0	0	0	22	0
1960	11	1	19	8	26	4	0	26	5
1961	9	9	16	2	27	2	0	35	0
1962	6	4	23	4	13	0	0	49	2
1963	0	0	100	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	33	67
1965	0	0	33	0	11	0	0	11	45
1966	0	0	100	0	0	0	0	0	0
All Years	7	3	21	8	20	3	0	32	5

Table 5. Number of INPFC chum salmon released and recovered by area of release from studies conducted in 1956-1966. Only recoveries in the year of tagging are presented.

Release Area Defined as the Rectangle	Number of Recoveries by Area										Total Recovery
	Number Release	Kotzebue	Norton Sound	Yukon River	Kuskokwim Bay	Bristol Bay	Alaska North	Peninsula South	Asian Coast and Japan	High Seas	
56 N to 54 N 172 W to 170 W	19	2	0	0	0	0	0	0	1	0	3
54 N to 52 N 172 W to 170 W	428	0	0	0	0	0	0	0	3	0	3
56 N to 54 N 170 W to 165 W	274	2	1	2	2	9	0	0	5	0	21
54 N to 52 N 170 W to 165 W	8,909	15	8	50	16	41	6	0	76	13	225 <sup>2</sup>
56 N to 54 N <sup>1</sup> 165 W to 160 W	499	0	0	4	4	6	2	0	0	0	16
54 N to 52 N 165 W to 160 W	127	0	0	2	1	0	1	0	2	1	7
Total	10,256	19	9	58	23	56	9	0	87	14	275

<sup>1</sup> Only two Bristol Bay recoveries were made from the releases into the Bering Sea portion of this area.

<sup>2</sup> Does not include two recoveries made between the Kuskokwim and Yukon area and one recovery each from the Strait of Georgia and Puget Sound.

Table 6. Number of INPFC chum salmon released and recovered by time period from tagging studies conducted in the area adjacent to the Alaska Peninsula and Aleutian Island chain, 1956-1966. Only recoveries made in the year of tagging are presented.

Release Period <sup>1</sup>	Number Released	Number of Recoveries by Area									Total Recovered
		Kotzebue	Norton Sound	Yukon River	Kuskokwim Bay	Bristol Bay	Alaska North	Peninsula South	Asian Coast and Japan	High Seas	
May 1	9	0	0	1	0	0	0	0	0	0	1
May 2	36	0	0	1	1	0	0	0	0	2	4
May 3	248	1	0	13	1	1	1	0	6	0	23 <sup>3</sup>
June 1	777	1	4	13	4	5	1	0	12	4	44
June 2	2,639	8	3	17	13	24	3	0	31	6	105
June 3	2,326	3	2	11	4	22	1	0	20	2	65
July 1	3,580	6	0	2	0	3	3	0	17	0	31
July 2	193	0	0	0	0	1	0	0	0	0	1
July 3	99	0	0	0	0	0	0	0	0	0	0 <sup>4</sup>
Aug. <sup>2</sup>	318	0	0	0	0	0	0	0	1	0	1 <sup>5</sup>
Sept.	31	0	0	0	0	0	0	0	0	0	0
Total	10,256	19	9	58	23	56	9	0	87	14	275

<sup>1</sup> Where: 1 < 11th day of the month  
2 = 11 to 20th day of the month  
3 > 20th day of the month

<sup>2</sup> Data were pooled by month for August and September

<sup>3</sup> Does not include 2 recoveries made between the Kuskokwim and Yukon areas.

<sup>4</sup> Does not include one recovery from Puget Sound.

<sup>5</sup> Does not include one Strait of Georgia recovery.

Table 7. Percentage of INPFC chum salmon released and recovered by time period from tagging studies conducted in the area adjacent to the Alaska Peninsula and Aleutian Island chain, 1956-1966. Only recoveries made in the year of tagging are presented.

Release period <sup>1</sup>	Number released	Number recovered	Percent Recovered By Area									% Recovered of Total Release
			Kotzebue	Norton Sound	Yukon River	Kuskokwim Bay	Bristol Bay	Alaska North	Peninsula South	Asian Coast and Japan	High Seas	
May 1	9	1	0	0	100	0	0	0	0	0	0	11.1
May 2	36	4	0	0	25	25	0	0	0	0	50	11.1
May 3	248	23	4	0	57	4	4	4	0	26	0	9.3
June 1	777	44	2	9	30	9	11	2	0	27	9	5.7
June 2	2,639	105	7	3	16	12	23	3	0	30	6	4.0
June 3	2,326	65	5	3	17	6	34	2	0	31	3	2.8
July 1	3,580	31	19	0	6	0	10	10	0	55	0	0.9
July 2	193	1	0	0	0	0	100	0	0	0	0	0.5
July 3	99	0	0	0	0	0	0	0	0	0	0	0.0
Aug. <sup>2</sup>	318	1	0	0	0	0	0	0	0	100	0	0.3
Sept.	31	0	0	0	0	0	0	0	0	0	0	0.0
All years	10,256	275										2.7

<sup>1</sup> Where: 1 < 11th day of the month  
2 = 11 to 20th day of the month  
3 > 20th day of the month

<sup>2</sup> Data were pooled by month for August and September.



Differences in time of release between recovery areas are discernible in Tables 6 and 7. From these data the mean date of release was calculated (Table 8) by first coding the release dates (CD), as 1 May = 1, 2 May = 2, 1 June = 32, ..., 31 July = 92, ....n for each recovery for a given area. The coded mean date of release (CMD) for that recovery area then became:

$$CMD = 1/n \sum_{i=1}^n CD_i$$

where the standard deviation (SD) was derived in a standard manner.

Table 8 presents the mean date of release for each recovery area in chronological order. The earliest mean (10 June) was observed for Yukon River recoveries (summer and fall runs combined) and the latest (24 June) in the Kotzebue area. It is important to note the magnitude of the standard deviations. Recovery areas which include a large region with many differently timed stocks would be expected to have a large variance. Therefore, one would expect the Asian Coast to have a large variance (12.4) as would the Yukon River (3.0) with its distinct summer and fall chum salmon runs (Table 8).

The comparatively large number of chum salmon recoveries from the Yukon River made it possible to separate early and late stocks. Summer chum salmon were defined for the purposes of this study as those which enter the Yukon River prior to 15 July and fall chum salmon as those which enter thereafter. Upriver recoveries were assigned as fall or summer chum salmon when possible by using information available on probable migration rate 32 to 48 km (20-30 mi) per day, time, and location of recovery. The recoveries designated as fall or summer chum salmon were then analyzed by period of release to determine if the mean date of release differs (Table 9) and if so which would be most vulnerable during June. These results indicate that summer run chum salmon were available for tagging earlier than the fall run with a 2 week difference in their mean date of release. Overall, it appeared that the fall chum salmon were more vulnerable to tagging in June where a good portion of the summer chum run may have passed through the area in May. With the exception of Yukon River summer stocks, the mean tagging date of all other Western Alaska chum salmon stocks appeared to fall well into June.

#### Stock Composition in the Release Area

Ideally, the percentage recovered by area would be applied directly to determine the actual stock composition at the time and place of release. Yet in doing so several strong assumptions must be fulfilled if the relative abundance of each stock at the time of tagging is to be based on its relative contribution to total recovery. Initially, during tagging all stocks must have been equally vulnerable to capture (Seber 1973). This requires that the number of fish tagged from each stock be in proportion to their relative abundance in a given area and time. A second assumption involves the loss of tagged fish. This would occur from natural mortality, tagging stress induced mortality, or tag loss. The analysis is not affected if tagged fish have a higher overall mortality than untagged fish as long as mortality is equal for stocks from all recovery areas. In addition, initial

Table 8. Timing statistics for INPFC tag releases of chum salmon in the area adjacent to the Alaska Peninsula and Aleutian Island chain, 1956-1966.

Area of Recovery	Mean Date of Release	S.D. <sup>1</sup>	Number of Recoveries <sup>2</sup>
Yukon River	June 10	13.0	58
High Seas	June 14	19.4	18
Kuskokwim Bay	June 14	9.9	23
Norton Sound	June 14	6.5	9
Asian Coast and Japan	June 19	12.4	87
North Alaska Peninsula	June 19	12.9	9
Bristol Bay	June 21	8.6	56
Kotzebue	June 24	9.7	19

<sup>1</sup> S.D. = Standard deviation of coded data, where 1 May = 1.

<sup>2</sup> Recaptured in the same year as released.

Table 9. INPFC tag release and recovery data for Yukon River chum salmon by time period, 1956-1966. Recoveries are from the year of tagging only.

Release Period <sup>1</sup>	Yukon River Chum Salmon		Percent Recovered		Total Recovered
	Run Designation Summer	Fall	Summer	Fall	
May 1	1	0	100	0	1
May 2	2	0	100	0	2
May 3	10	1	92	8	11
June 1	9	2	73	27	11
June 2	7	9	44	56	16
June 3	1	9	10	90	10
July 1	0	2	0	100	2
Total	30	23	57	43	53 <sup>2</sup>
Mean date of release	June 4	June 20			
S.D. <sup>3</sup>	11.8	9.0			

<sup>1</sup> Where:

- 1 < 11th day of the month
- 2 = 11 to 20th day of the month
- 3 > 20th day of the month

<sup>2</sup> Does not include five recoveries for which run could not be assigned.

<sup>3</sup> S.D. = Standard deviation of coded data, where 1 May = 1.

tag loss would most likely be shared equally amongst the different stocks being tagged and would not alter the relative frequency of recovery. It is likely however, that mortality and the shedding of tags are time dependent, often being modeled as an exponential decay process. Therefore, the greater the time between release and recovery the greater the mortality and tag loss in absolute numbers. This would infer that a recovery area distant to the release area, such as the Asian Coast and Kotzebue, would be under-represented in the total recoveries in comparison to nearby areas, having lost more fish through mortality or tag loss. In addition Asian chum salmon must pass through a massive high seas gill net fishery before reaching home streams. The high seas recoveries could be predominantly Asian origin fish representing a mortality source other stocks may escape. If different levels of mortality or tag loss are suffered by the tagged group the similarity between the recovery distribution and the stock composition in the release area is weakened.

One of the most important assumptions involves tag recovery and reporting. To determine relative stock strength from the recovery distribution, it must be assumed that all tags recovered were reported. In addition the recovery rate must be equal or known for all areas. For recovery rates to be equal it requires that similar percentages of each stock were surveyed for recoveries or that a tagged fish has a similar probability of recapture for each area. If recovery rates are unequal but known, adjustments can be made to the number of recoveries by area to make them comparable. If one area has a far superior tag recovery program it may provide a disproportionately high number of recoveries to the total. This assumption is most likely violated in this analysis as several features of the recovery areas indicate this. Japan may have an adequate recovery program yet information on U.S.S.R. harvests is difficult to obtain resulting in a very weak recovery program. In the U.S., tagging conducted by FRI was followed up by a tag recovery program and a reward system for returns, yet Western Alaska commercial chum salmon fisheries were not well developed during this period and most tag returns were obtained from subsistence fishermen and research projects conducted by federal and state agencies. In addition, the problem of overlooking tags in large catches would be greatest in the Bristol Bay commercial salmon fishery where chum salmon are far less abundant than sockeye salmon. Sockeye salmon virtually saturate the fishery during peak cycle years. How these factors interact is unknown though it would not be safe to assume a constant recovery rate for all areas and adjustments cannot be made as actual recovery rates are unknown.

In summary, the percentage recovered by area (Tables 4 and 7) cannot be applied directly to determine the stock composition in the tagging area. The assumptions previously discussed are unlikely to be met with the most obvious violation being that recovery rates were not constant or known in all areas.

#### SUMMARY

Chum salmon tagged in the vicinity of the Alaska Peninsula and Eastern Aleutian Island chain, 1956-1966, were recovered throughout Western Alaska and along the Asian Coast. Fish were tagged from May through July and differences in arrival times for the various chum salmon stocks were apparent from the differing mean dates of release. Summer run chum salmon from the Yukon River dominated the

recoveries from May and early June releases. Most recoveries from tagging throughout June were from the Bristol Bay and the Asian Coast. It was found for the Yukon River that the fall run chum salmon were available for tagging in mid to late June. The latest Western Alaska stock to be tagged was from Kotzebue with a 24 June mean date of release.

Stock composition at the time and place of tag release could not be based on the percentage recovered from each area. Recovery rates were not known to be equal. This then severely weakens any conclusions drawn in regards to the similarity between the release and recovery distributions. In addition, the presence of time dependent mortality or a tag shedding process would negate the comparison of recoveries in nearby and distant areas.

#### ACKNOWLEDGMENTS

Over 90% of the recoveries of tagged chum salmon discussed in this report were released during studies conducted by the Fisheries Research Institute (FRI) of the University of Washington while under contract to the Bureau of Commercial Fisheries of the U.S. Fish and Wildlife Service. Today, these data and the entire database from INPFC related studies are maintained at FRI. I wish to thank Colin Harris of FRI for providing release and recovery information and for reviewing the manuscript.

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## APPENDICES

Date and location data for each chum salmon recovered from INPFC tagging studies conducted in the area adjacent to the Alaska Peninsula and Aleutian Island chain, 1956-1966.

Appendix Table 1. Description of recovery area codes. (From Aro et al. 1971).

Area Number	Area Name
	<u>Asia</u>
01	Honshu Island
02	Hokkaido Island
03	Kuril Islands
04	Japan Sea Coast of U.S.S.R., south of Reineke Island
05	Amur River
06	Sakhalin Island
07	Okhotsk Sea Coast, Reineke Island to Cape Tolstoi
08	Shelekhova Bay, Cape Tolstoi to Cape Yuzhnyi
09	West Kamchatka, South of Cape Yuzhnyi
10	East Kamchatka, South of Cape Afrika
11	Kamchatka River
12	Karaginskii District, Cape Afrika to Cape Olyutorskii
13	Siberian Coast, North of Cape Olyutorskii
14	Anadyr River
15	U.S.S.R. Unknown
16	Asian Coastal - Other
17	Asian Coastal - Unknown
	<u>High Seas</u>
20	Sea of Japan
21	Okhotsk Sea
22	Bering Sea West of 170°E
23	Bering Sea 170°E - 175°E
24	Bering Sea 175°E - 180°
25	Bering Sea 180° - 175°W
26	Bering Sea East of 175°W
27	North Pacific South of 48°N and West of 165°E
28	North Pacific South of 48°N 165°E - 175°W
29	North Pacific South of 48°N and West of 160°E
30	North Pacific South of 48°N 160°E - 165°E
31	North Pacific South of 48°N 165°E - 170°E
32	North Pacific South of 48°N 170°E - 175°E
33	North Pacific South of 48°N 175°E - 180°
34	North Pacific South of 48°N 180° - 175°W
35	North Pacific 160°W - 175°W
36	North Pacific 145°W - 160°W
37	North Pacific North of 50°N and East of 145°W
38	North Pacific South of 50°N and East of 145°W
39	High Seas - Unknown

-Continued-



Appendix Table 1. Description of recovery area codes (continued).

Area Number	Area Name
<u>Alaska</u>	
40	North of Cape Prince of Wales (Kotzebue Sound)
41	Norton Sound Area (Cape Prince of Wales to Stuart Island)
42	Yukon River
43	Yukon River to Kuskokwim River (Cape Romanzof to Cape Avinof)
44	Kuskokwim River and Bay
45	Togiak Vicinity (Cape Newenham to Cape Constantine)
46	Nushagak Vicinity
47	Naknek-Kvichak
48	Egegik
49	Ugashik
50	Ugashik to Unimak Pass (North side of Alaska Peninsula)
51	Bristol Bay Unknown (Somewhere within areas 45-49)
52	Aleutian Islands (West of Unimak Pass)
53	South side of Alaska Peninsula West of 159°W
54	South side of Alaska Peninsula East of 159°W
55	Kodiak Island, Shelikof Strait side
56	Kodiak Island, Gulf of Alaska side
57	Cook Inlet (Cape Douglas to Gore Point)
58	Southeast side Kenai Peninsula (Gore Point to Cape Fairfield)
59	Prince William Sound (Cape Fairfield to Point Steele, Hitchinbrook Island)
60	Copper River and Bering River
61	Yakutat District
62	Southeastern Alaska, Icy Strait District
63	Southeastern Alaska, Chatham District
64	Southeastern Alaska, Petersburg District
65	Southeastern Alaska, Prince of Wales District
66	Southeastern Alaska, Ketchikan District
67	Southeastern Alaska - Unknown
68	Alaska - Other
69	Alaska - Unknown
<u>British Columbia</u>	
70	Queen Charlotte Islands
71	Nass River
72	Skeena River
73	Central British Columbia
74	Rivers - Smith Inlets
75	Queen Charlotte Strait - Johnstone Strait
76	Strait of Georgia
77	Fraser River and Strait of Juan de Fuca (Canadian waters)
78	West Coast of Vancouver Island
79	British Columbia - Other and Unknown

-Continued-

Appendix Table 1. Description of recovery area codes (continued).

Area Number	Area Name
<u>Washington, Oregon, Idaho, and California</u>	
80	Strait of San Juan de Fuca (United States waters)
81	Salmon Bank Area
82	Skagit River
83	Puget Sound
84	Outer Washington Coast South of Cape Flattery
85	Columbia River (Including entire Columbia River drainage)
89	Washington State - Unknown
90	Oregon (excluding Columbia River drainage)
91	California
<u>Other Areas</u>	
98	North America Coastal - Unknown
99	Entirely Unknown

Appendix Table 2. Date and location of release and recovery of each chum salmon recovered from INPFC tagging studies conducted in the area adjacent to the Alaska Peninsula and Aleutian Island chain, 1956-1966. Only recoveries made in the year of tagging are presented. (From Aro et al. 1971).

Release			Recovery			
Location <sup>1</sup>		Date	Area <sup>2</sup>	Location		Date <sup>3</sup>
Lat.	Long.			Lat.	Long.	
5225N	16823W	061562	40	6652N	16238W	0730
5250N	16824W	062860	40	6650N	16110W	0805
5250N	16824W	062860	40	6650N	16110W	0920
5253N	16825W	062960	40	6650N	16110W	0826
5247N	16825W	060961	40	6650N	16110W	0805
5238N	16846W	053162	40	6652N	16238W	0809
5233N	16917W	070660	40	6650N	16110W	0909
5233N	16917W	070660	40	6650N	16110W	0917
5320N	16712W	062161	41	6355N	16050W	0813
5301N	16751W	061862	41	6356N	16050W	0720
5301N	16751W	061862	41	6355N	16050W	0719
5253N	16816W	060960	41	6430N	16300W	0132
5250N	16822W	061061	41	6355N	16050W	0132
5248N	16830W	060961	41	6328N	16200W	0705
5249N	16831W	060459	41	6430N	16300W	0708
5246N	16836W	061261	41	6440N	16120W	0132
5330N	16515W	052460	42	6205N	16330W	0701
5330N	16610W	052760	42	6635N	14415W	0132
5300N	16700W	051860	42	6500N	15731W	0717
5322N	16702W	061956	42	6420N	16440W	0715
5322N	16702W	061456	42	6250N	16350W	0723
5319N	16710W	062161	42	6232N	16455W	0803
5318N	16711W	070361	42	6232N	16455W	0807
5312N	16721W	062961	42	6500N	15731W	0822
5318N	16721W	062961	42	6420N	16440W	0724
5254N	16726W	052862	42	6200N	16310W	0629
5254N	16726W	052862	42	6212N	16352W	0626
5257N	16726W	052862	42	6240N	16440W	0623
5257N	16726W	052862	42	62—N	163—W	0625
5259N	16742W	052962	42	6155N	16256W	0627
5259N	16742W	052962	42	6235N	16450W	0628
5301N	16751W	061862	42	6515N	15200W	0800
5301N	16751W	061862	42	6155N	16256W	0717
5305N	16804W	060956	42	6245N	16010W	0719
5307N	16806W	060856	42	6210N	16150W	0712
5257N	16810W	061060	42	6232N	16455W	0132
5255N	16814W	061060	42	6450N	14915W	0909
5255N	16814W	061060	42	6300N	16350W	0703
5255N	16818W	061760	42	6244N	16428W	0715
5255N	16818W	061760	42	6445N	15800W	0802

-Continued-

Appendix Table 2. (Continued).

Release			Recovery			
Location <sup>1</sup>		Date	Area <sup>2</sup>	Location		Date <sup>3</sup>
Lat.	Long.			Lat.	Long.	
5255N	16819W	061160	42	6210N	16300W	0709
5255N	16819W	061160	42	6500N	15731W	0905
5254N	16821W	061660	42	6635N	14415W	0929
5254N	16821W	061660	42	6430N	14905W	0929
5254N	16821W	061660	42	6445N	15530W	0823
5254N	16822W	061462	42	62—N	164—W	0710
5225N	16823W	061562	42	6235N	16450W	0804
5250N	16824W	062860	42	6210N	15945W	0810
5250N	16824W	062860	42	6240N	16440W	0912
5247N	16828W	060856	42	6150N	16255W	0715
5251N	16829W	062960	42	6240N	16440W	0920
5251N	16829W	062960	42	6445N	15700W	1001
5248N	16830W	060961	42	6235N	16450W	0703
5248N	16830W	060961	42	6212N	16352W	0710
5249N	16831W	060459	42	6200N	16300W	0132
5249N	16831W	060459	42	6212N	16352W	0703
5249N	16831W	060459	42	6150N	16200W	0630
5249N	16831W	060459	42	6145N	16130W	0706
5247N	16838W	061461	42	6240N	16440W	0724
5247N	16838W	061561	42	6242N	16432W	0824
5244N	16845W	053162	42	6240N	16440W	0620
5244N	16845W	053162	42	6212N	16352W	0725
5302N	16519W	051565	42	6250N	16440W	0703
5302N	16519W	051565	42	6220N	16420W	0622
5323N	16632W	060765	42	6212N	16352W	0924
5301N	16727W	052862	43	6230N	16520W	0626
5301N	16727W	052862	43	6153N	16547W	0628
5325N	16606W	061162	44	6003N	16212W	0714
5340N	16612W	061656	44	6130N	16050W	0730
5340N	16612W	061656	44	6135N	15918W	0731
5338N	16613W	061556	44	6047N	16144W	0711
5323N	16659W	061456	44	6047N	16144W	0718
5300N	16700W	051860	44	6130N	16050W	0616
5322N	16702W	061956	44	6130N	15940W	0717
5253N	16816W	060960	44	6130N	16050W	0714
5255N	16819W	061160	44	6130N	15940W	0716
5255N	16819W	061160	44	6047N	16144W	0702
5254N	16821W	061660	44	6045N	16130W	0720
5254N	16822W	061462	44	6010N	16220W	0725
5254N	16823W	061760	44	6130N	16050W	0700
5246N	16830W	060961	44	6135N	15922W	0810
5249N	16831W	060459	44	6047N	16144W	0630
5249N	16831W	060459	44	6135N	15918W	0715
5340N	16612W	061656	45	5901N	16028W	0724
5314N	16644W	070460	45	5901N	16028W	0730
5319N	16710W	062161	45	5901N	16025W	0718
5318N	16721W	062961	45	5901N	16025W	0727
5255N	16814W	061060	45	5901N	16028W	0714

-Continued-

Appendix Table 2. (Continued).

Release			Recovery			
Location <sup>1</sup>		Date	Area <sup>2</sup>	Location		Date <sup>3</sup>
Lat.	Long.			Lat.	Long.	
5255N	16818W	061760	45	5901N	16028W	0721
5254N	16821W	061660	45	5901N	16028W	0712
5246N	16836W	061261	45	5901N	16028W	0814
5323N	16659W	061456	46	5845N	15840W	0132
5309N	16703W	061362	46	5845N	15840W	0712
5318N	16713W	062961	46	5845N	15840W	0715
5318N	16721W	062961	46	5845N	15840W	0719
5301N	16751W	061862	46	5845N	15840W	0707
5254N	16820W	061760	46	5845N	15840W	0713
5247N	16830W	062365	46	5845N	15840W	0713
5309N	16703W	061362	47	5845N	15710W	0709
5319N	16710W	062161	47	5845N	15710W	0713
5319N	16710W	062161	47	5845N	15710W	0711
5319N	16710W	062161	47	5845N	15710W	0715
5303N	16757W	062056	47	5845N	15710W	0711
5303N	16804W	060956	47	5845N	15710W	0710
5255N	16814W	061060	47	5845N	15710W	0702
5253N	16819W	063060	47	5845N	15710W	0725
5254N	16820W	061760	47	5845N	15710W	0708
5254N	16823W	061760	47	5845N	15710W	0709
5247N	16825W	060961	47	5845N	15710W	0724
5251N	16829W	062960	47	5845N	15710W	0728
5253N	16832W	070661	47	5845N	15710W	0727
5250N	16837W	061761	47	5845N	15710W	0718
5247N	16838W	061561	47	5845N	15710W	0706
5244N	16845W	053162	47	5845N	15710W	0706
5304N	16713W	061362	48	5815N	15735W	0712
5248N	16830W	060961	48	5815N	15735W	0629
5324N	16616W	061162	49	5735N	15740W	0706
5318N	16647W	070860	49	5735N	15740W	0726
5326N	16605W	061357	50	5610N	16025W	0710
5312N	16649W	070360	50	5600N	16040W	0725
5255N	16819W	061160	50	5630N	15945W	0801
5253N	16819W	063060	50	5600N	16120W	0728
5246N	16830W	060961	50	5620N	16015W	0720
5246N	16836W	061261	51	0000	10000	0707
5309N	16711W	080260	76	4949N	12436W	1017
5246N	16838W	072161	83	4733N	12302W	1221
5535N	16335W	062461	46	5845N	15840W	0718
5558N	16459W	071562	47	5845N	15710W	0724
5432N	163--W	070156	42	6240N	16440W	0825
5428N	164--W	061955	42	6212N	16352W	0710
5423N	16411W	062156	42	6150N	16200W	0725
5423N	16411W	062156	42	6240N	16440W	0713
5447N	16251W	062356	44	6047N	16144W	0713
5426N	16409W	061956	44	6130N	15940W	0721
5426N	16409W	061956	44	5930N	16218W	0729
5429N	16411W	062956	44	6135N	15918W	0700
5432N	16244W	062456	46	5845N	15840W	0717
5429N	16411W	062956	46	5845N	15840W	0713
5425N	16413W	062056	46	5845N	15840W	0709

-Continued-

Appendix Table 2. (Continued).

Release			Recovery			
Location <sup>1</sup>		Date	Area <sup>2</sup>	Location		Date <sup>3</sup>
Lat.	Long.			Lat.	Long.	
5425N	16413W	062056	46	5845N	15840W	0705
5432N	16303W	070156	50	5530N	16230W	0802
5432N	16303W	070156	50	5445N	16325W	0705
5500N	17010W	062061	02	4404N	14512E	0909
5500N	17010W	062061	40	6700N	16025W	0704
5500N	17010W	062061	40	6648N	16105W	0804
5233N	17035W	070657	02	4406N	14415E	1027
5233N	17035W	070657	02	4406N	14415E	1127
5233N	17035W	070657	03	4400N	146—E	1109
5449N	16940W	062361	02	4424N	14520E	1016
5500N	16955W	062261	02	4404N	14512E	1024
5511N	16950W	062161	02	4214N	14019E	1115
5511N	16950W	062161	02	4233N	14022E	1020
5416N	16936W	062860	10	5600N	16230E	0132
5545N	16625W	062361	40	6740N	16255W	0927
5500N	16955W	062261	40	6700N	16234W	0926
5500N	16955W	062261	41	6445N	16155W	0715
5438N	16849W	062960	42	6500N	15731W	0908
5449N	16940W	062861	42	6212N	16352W	0132
5422N	16938W	063060	44	6139N	15944W	0803
5422N	16938W	063060	44	6133N	16023W	0731
5416N	16936W	062860	45	5901N	16028W	0715
5438N	16849W	062960	46	5857N	15827W	0720
5416N	16936W	062860	46	5857N	15827W	0717
5422N	16938W	063060	46	5857N	15827W	0711
5416N	16936W	062860	47	5845N	15710W	0716
5422N	16938W	063060	47	5845N	15710W	0720
5422N	16938W	063060	48	5815N	15735W	0718
5422N	16938W	063060	49	5735N	15740W	0717
5422N	16938W	063060	51	58—N	160—W	0722
5325N	16851W	062060	02	4300N	14416E	1026
5325N	16851W	062060	11	5615N	16230E	0824
5325N	16851W	062060	42	6635N	14415W	0922
5326N	16935W	062060	46	5845N	15840W	0713
5326N	16935W	062060	46	5845N	15840W	0712
5326N	16935W	062060	46	5845N	15840W	0709
5325N	16851W	062060	47	5845N	15710W	0714
5326N	16935W	062060	49	5735N	15740W	0705
5325N	16851W	062060	50	5500N	16400W	0708
5312N	16721W	062961	01	—N	1—W	1210
5254N	16814W	062162	01	3926N	14200E	1121
5247N	16838W	061461	01	3738N	14110E	1010
5246N	16838W	062660	01	3940N	14155E	1126
5314N	16644W	070460	02	4402N	14512E	1109
5320N	16649W	070260	02	4410N	14404E	1211
5312N	16649W	070360	02	4404N	14458E	1027
5313N	16650W	070360	02	4322N	14513E	1009
5313N	16650W	070360	02	4245N	14342E	1010
5313N	16650W	070360	02	4402N	14510E	1114

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Appendix Table 2. (Continued).

Release			Recovery			
Location <sup>1</sup>		Date	Area <sup>2</sup>	Location		Date <sup>3</sup>
Lat.	Long.			Lat.	Long.	
5321N	16701W	081356	02	4405N	14500E	1108
5309N	16703W	061362	02	4355N	14440E	1015
5309N	16703W	061362	02	4331N	14456E	0909
5318N	16713W	062961	02	4408N	14403E	1102
5304N	16713W	061362	02	4401N	14512E	1003
5239N	16719W	070560	02	4410N	14404E	1127
5318N	16721W	062961	02	4200N	14310E	1108
5257N	16726W	052862	02	4402N	14512E	1013
5302N	16730W	070258	02	4345N	14440E	1026
5302N	16730W	070358	02	4345N	14505E	1027
5302N	16730W	070258	02	4405N	14500E	1012
5302N	16730W	070258	02	4345N	14440E	1028
5250N	16809W	060362	02	4407N	14408E	1006
5256N	16815W	062162	02	4244N	14345E	1006
5253N	16816W	060960	02	4247N	14335E	1026
5255N	16819W	061160	02	4227N	14326E	0710
5253N	16819W	063060	02	4410N	14404E	1026
5252N	16822W	061762	02	4208N	14254E	1120
5252N	16822W	061762	02	4408N	14404E	1025
5250N	16824W	062860	02	4357N	14402E	1127
5253N	16825W	062960	02	4355N	14427E	1005
5247N	16825W	060961	02	4245N	14345E	1014
5246N	16836W	061261	02	4315N	14530E	1021
5250N	16837W	061761	02	4355N	14440E	1015
5247N	16838W	061561	02	4230N	14020E	1107
5247N	16838W	061461	02	4328N	14515E	1008
5246N	16838W	062626	02	4355N	14404E	1028
5245N	16845W	070660	02	4422N	14318E	1129
5245N	16845W	070660	02	4353N	14442E	1102
5247N	16830W	062365	03	4345N	14645E	1108
5249N	16736W	062562	06	5200N	14310E	0802
5255N	16818W	061760	06	5330N	14230E	1011
5338N	16613W	061556	10	—N	1—E	0000
5254N	16821W	061660	10	5304N	15834E	0132
5254N	16823W	061760	10	—N	1—E	0816
5319N	16710W	062161	11	5615N	16220E	0819
5302N	16742W	061862	11	5615N	16220E	0811
5230N	16803W	061762	11	5615N	16220E	0821
5250N	16809W	060362	11	5615N	16220E	0826
5253N	16816W	060960	11	5610N	16230E	0818
5255N	16819W	061160	11	5610N	16230E	0912
5252N	16822W	061762	11	5615N	16220E	0917
5247N	16825W	060961	11	5615N	16220E	0809
5304N	16713W	061362	12	6100N	17020E	0812

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Appendix Table 2. (Continued).

Release			Recovery			
Location <sup>1</sup>		Date	Area <sup>2</sup>	Location		Date <sup>3</sup>
Lat.	Long.			Lat.	Long.	
5303N	16757W	062056	12	5951N	16325E	0814
5254N	16815W	061060	12	6026N	16936E	0830
5249N	16831W	060459	12	6000N	16540E	0132
5249N	16831W	064059	12	6000N	16540E	0132
5238N	16846W	053162	12	6010N	16520E	0820
5325N	16606W	061162	14	6445N	17740E	0132
5325N	16606W	061162	14	65—N	177—E	0820
5309N	16730W	061362	14	65—N	177—E	0132
5304N	16713W	061362	14	6400N	17800E	0132
5304N	16713W	061362	14	6445N	17740E	0132
5257N	16726W	052862	14	6500N	17500E	0132
5307N	16806W	060856	14	6450N	17600E	0821
5244N	16811W	061061	14	6453N	17615E	0812
5255N	16819W	061160	14	6450N	17600E	0132
5250N	16822W	061061	14	6450N	17600E	0820
5254N	16822W	061462	14	6445N	17740E	0132
5253N	16832W	070661	14	6450N	17600E	0808
5238N	16846W	053162	14	6445N	17740E	0132
5236N	16700W	060664	14	64—N	17730E	0802
5309N	16703W	061362	21	5300N	15458E	0807
5300N	16700W	051860	22	5827N	16652E	0703
5303N	16757W	062056	22	5834N	16736E	0723
5236N	16700W	060664	23	5837N	17448E	0704
5302N	16519W	051565	25	5836N	17629W	0701
5312N	16647W	060765	25	5836N	17759W	0719
5254N	16820W	061760	25	5830N	17549W	0703
5254N	16821W	061660	25	5752N	17750E	0707
5254N	16821W	061660	25	5738N	17625W	0703
5254N	16823W	061760	25	5731N	17616W	0706
5247N	16830W	062365	25	5818N	17723W	0719
5248N	16830W	062365	32	5018N	17217E	0725
5307N	16806W	060856	33	5112N	17829E	0623
5318N	16647W	070360	40	6650N	16110W	0827
5320N	16649W	070260	40	6630N	16300W	0731
5313N	16650W	070260	40	6650N	16110W	0905
5239N	16719W	070560	40	6700N	16234W	0920
5256N	16815W	062162	40	6735N	16304W	0804
5253N	16819W	063060	40	6730N	16300W	0929
5254N	16821W	061660	40	6650N	16110W	0800
5315N	16330W	052757	11	55—N	162—E	0816
5340N	16345W	052757	14	6450N	17600E	0808

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Appendix Table 2. (Continued).

Release			Recovery			
Location <sup>1</sup>		Date	Area <sup>2</sup>	Location		Date <sup>3</sup>
Lat.	Long.			Lat.	Long.	
5326N	16110W	060564	25	5920N	17805W	0702
5325N	16100W	053063	42	6235N	16450W	0625
5314N	16257W	050466	42	6155N	16256W	0710
5345N	16410W	052957	44	6130N	16050W	0715
5340N	16345W	052757	50	5500N	16230W	0132

<sup>1</sup> Location

Lat. = Degrees and minutes of north latitude, e.g., 15630E = 51°23' North.

Long. = Degrees and minutes of east or west longitude, e.g., 15630E=156°30' East.

<sup>2</sup> For area code description see Appendix Table 1.

<sup>3</sup> Recoveries are in the same year as release where the first two digits indicate the month and the last two digits indicate the day. The month is indicated as follows:

00 = Recovery month and year unknown.

01 = Recovery year is known but month and day are unknown.

02-31 = Recovery month in year of tagging.

The day of recovery is indicated as follows:

00 = Day of month unknown.

01-31 = Day of month

32 = Day and month unknown but year known.